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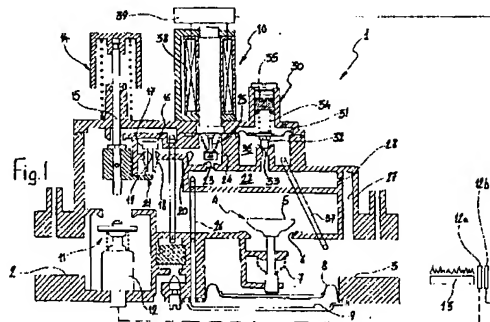
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(54) A valve unit for modulating the delivery pressure of a gas

(57) A valve unit for modulating the delivery pressure of a gas comprises a servo-valve (4) having a closure member (5) with diaphragm control (8), the diaphragm (8) being subjected, on one side, to the gas-delivery pressure and, on the other side, to a control pressure (Pt) established in a control chamber (9) of the servo-valve (4), a pressure-regulation device associated with the servo-valve (4) and comprising a modulation valve (10;51) for modulating the control pressure and consequently the gas-delivery pressure, actuator means for the operative control of the modulation valve (10;51), and a circuit (39) for driving the actuator means. The driver circuit (39) comprises means for generating an operative modulation-valve driving signal (S) of constant frequency, with a preselected period (T), and means for duration modulation of the signal amplitude within the

period (T) so as to modulate the control pressure (Pt) in a proportionally correlated manner.



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## Description

[0001] The present invention relates to a valve unit for modulating the delivery pressure of a gas, according to the preamble to the main claim.

5 [0002] As is well known, these units are used for controlling the delivery of a gas to a burner or to another similar user. In this field, the invention is suitable, particularly but not exclusively, for modulating the delivery pressure of fuel gas in space-heating apparatus. More particularly, the invention may be used for modulating the delivery pressure in gas fires, for example, decorative fires which have burners and for which regulation of the flame, and consequently a modulation of the gas-delivery pressure between maximum and minimum pressure values permitted for correct operation, is also required.

10 [0003] In these units, it is known to regulate the gas-delivery pressure in controlled manner in accordance with predetermined parameters, for example, measured, by an electrical current supplied to the solenoid of an electromagnetic actuator of the valve unit. Typically, the control, that is, the cutting-off of the gas supply, is performed by a shut-off valve, whereas the modulation of the delivery pressure between the minimum and maximum values may be performed by means of a servo-valve subservient to a diaphragm modulation unit. The diaphragm of the modulation unit is acted on, on one side, by the gas-delivery pressure as detected in the delivery duct to the user and, on the other side, by a resilient load which is subjected to the action of the movable element of an electromagnet and is variable between a minimum value and a maximum value, in dependence on the current driving the electromagnet.

15 [0004] In these valve units there is a need to ensure the delivery-pressure control and modulation function even in the absence of an electrical supply from the mains which is normally used for driving the above-mentioned electromagnetic actuators. For this purpose, there is provision for the use, as voltage generators, of thermogenerator devices such as thermocouples and thermopiles which can supply safety electromagnetic devices, purely for the function of shutting-off the gas supply. However, by their nature, these thermogenerating devices can generate relatively low electrical voltages or powers and although, on the one hand, these effectively ensure control of the gas shut-off function, on the other hand, they are insufficient to drive the electromagnetic actuators provided for the delivery-pressure modulation function. Pressure modulation in fact requires powers of a few tens of volts greater than the powers which can be generated by the thermopile safety devices normally used in these valve units.

20 [0005] The problem upon which the present invention is based is that of providing a valve unit which is designed structurally and functionally so as to overcome all of the disadvantages complained of with reference to the prior art mentioned.

30 [0006] This problem is solved by the invention by means of a valve unit formed in accordance with the appended claims.

[0007] The characteristics and the advantages of the invention will become clearer from the following detailed description of a preferred embodiment thereof, described by way of non-limiting example with reference to the appended drawings, in which:

35 Figures 1 and 2 are longitudinal sections of two respective variants of the valve unit according to the invention,

Figures 3, 4, 6, 7 and 9 are graphs showing characteristic pressure-time curves of the valve unit of the invention, in various operative conditions, and

40 Figures 5 and 8 are graphs showing characteristic curves of a driving signal of the valve unit of the invention, in two different operative conditions.

45 [0008] With reference to Figure 1, a first embodiment of the valve unit according to the present invention for modulating the delivery pressure of a fuel gas delivered to a burner or to another similar user, not shown in the drawing, is generally indicated 1. The gas is supplied to the unit 1 through a supply duct 2 and is delivered thereby through a delivery duct 3.

[0009] The ducts 2 and 3 are separated by a servo-valve 4 comprising a closure member 5 which is urged resiliently into closure on a seat 6 by the resilient load of a spring 7 and which can be opened by a diaphragm 8 sensitive to the pressure differential existing between the pressure  $P_u$  in the delivery duct 3, on one side, and by the pressure  $P_t$  in a control chamber 9, on the other side. The value of the control pressure  $P_t$  is controlled by the operation of a modulation valve, indicated 10 and described in detail below.

50 [0010] The valve unit 1 also comprises a safety valve 11 operated by an electromagnetic unit 12 supplied by a thermogenerator device, for example, including a thermocouple 12a heated by the flame of a pilot burner 13, shown schematically in the drawings. The electromagnetic unit 12 is set manually by means of a setting member 14 provided with an operating rod 15 so as to open the safety valve 11 and to allow the gas to flow towards the delivery duct 3.

55 [0011] The valve unit 1 also has a second safety valve 16 the closure member 17 of which is urged by spring 18 into closure on a valve seat 19. The seat 19 puts the supply duct 2 selectively into communication with a duct 20 for tapping off the gas delivered to the input of the valve unit. The safety valve 16 has operating means 21 mechanically coupled to the manual setting member 14 of the safety valve 11. The mechanical coupling is such that, during setting, the safety valve 16 is kept closed and is acted on so as to be opened by the operating means 21,

thus allowing the gas to flow through the tapping-off duct 20, only upon the release of the setting member 14 after the pilot flame has been lit.

**[0012]** The duct 20 is in communication with a chamber 22 through a valve seat 23 onto which a closure member 24, movable by the action of a control rod 25 of the modulation valve 10, is urged into closure.

**[0013]** The chamber 22 is always in communication with the control chamber 9 through a transfer duct 26, and with the delivery duct 3 through a duct 27. The duct 27 is in communication with the chamber 22 through a calibrated hole 28.

**[0014]** A valve for regulating the maximum delivery pressure is indicated 30. The valve 30 has a diaphragm 31 fixed to a plate holding a closure member 32 associated with a corresponding valve seat 33. The diaphragm 31 is subjected, on one side, to the load which is exerted by a spring 34 and which can be adjusted by screwing of a spring-holder 35 and, on the other side, to the pressure existing in a chamber 36. The chamber 36 is in communication with the chamber 22 through the valve seat 33 and with the delivery duct 3 through a transfer duct 37.

**[0015]** The modulation valve 10 comprises an actuator 38 with an electromagnet the solenoid of which is supplied with an operative signal S controlled by a driver circuit 39 shown only schematically in the drawings. Alternatively, the actuator of the modulation valve 10 may be of a piezoelectric type, for example, with a double blade.

**[0016]** Means are provided in the driver circuit 39 for generating the signal S with a curve (as a function of time) of the type shown in Figure 5. The signal S is of constant frequency with a preselected period T and its amplitude is variable within the period T. More particularly, the pulsed signal S is generated as a continuous signal within a first interval T1 and as a signal with zero amplitude in a second interval T2 sequential with the first and such that the overall duration of the intervals T1 and T2 is equal to the period T. The signal S is preferably an electrical voltage signal with which the solenoid of the modulation valve 10 is supplied.

**[0017]** With reference now to Figure 3, a first characteristic curve of the pressure Pt, as a function of time, generated in the chamber 22 when the closure member 24 of the valve 10 is kept in the open condition throughout the period of time in which gas enters the chamber, is indicated 40, and the curve of the discharge of the gas from the chamber 22, in which the pressure Pt decreases over time, tending towards zero, is indicated 41. Figure 4 shows the pressure-time graph of the control pressure Pt in the condition in which the modulation valve 10 is supplied with the driving signal S of Figure 5. It will be noted that the pressure Pt tends to increase during the intervals T1 and to decrease during the intervals T2, varying in accordance with the curves 40 and 41 shown in Figure 3, respectively. It is also pointed out that the pressure-time function can be broken down into the sum of a first portion and a second portion, that is, a continuous portion and an oscillating portion, respectively, of which the first, continuous portion, shown in Figure 6, is constituted by the integrated mean value of the pressure function Pt of Figure 4. The control pressure Pt actually detectable in the control chamber 9 is constituted solely by the continuous portion of the function, in addition to the oscillating portion which, however, since it has a mean value of zero within the period, does not affect the integrated mean value of the pressure Pt.

**[0018]** Figure 7 shows a curve similar to that of Figure 4 in which a ratio, indicated D, between the interval T1 and the period T, greater than the ratio adopted for the curve of Figure 4 has been selected. As will be noted, the curve of Figure 7 represents an integrated mean value of the pressure Pt which is shown in Figure 9 and which is greater than that of Figure 6.

**[0019]** Modulation of the ratio D by adjusting the duration of the interval T1 relative to the selected period T achieves, in a proportionally correlated manner, continuous modulation of the integrated mean value of the control pressure Pt, and consequently of the gas-delivery pressure in the duct 3, with consequent modulation of the flow-rate of the gas. The pressure Pt is modulated within a range of values between a maximum pressure value established by the valve 30 and a minimum pressure value set by the minimum value adopted by the ratio D.

**[0020]** In the embodiment of Figure 1, the modulation valve 10 is also arranged to perform the function of shutting off the flow of gas delivered to the input of the valve unit 1.

**[0021]** Moreover, the driving signal S controlled by the circuit 39 is preferably selected as a low-voltage signal, for example, with an order of magnitude of hundreds of millivolts. Owing to the relatively low driving voltages required, the modulation valve can also advantageously be supplied by the energy produced by the thermoelectric phenomenon in a thermopile 12b of the thermogenerator device.

**[0022]** Figure 2 shows a second embodiment of the valve unit according to the invention, generally indicated 50, in which details similar to those of the previous embodiment are indicated by the same reference numerals. The unit 50 differs from that of the previous embodiment mainly in that, for modulating the control pressure Pt, it has a valve 51 the modulation function of which is similar to that of the valve 10 of the previous embodiment, to which reference should be made for a detailed description. For the function of shutting off the gas flow, the valve unit 50 has a further ON-OFF valve 52 which, unlike the valve 51, is not supplied with the driving signal of modulated duration.

**[0023]** The modulation valve 51 comprises a closure body which is urged into closure on a valve seat 53 through which the chamber 22 is in communication with a duct 54. The duct 54 opens into the duct 27 through a hole 55 acted on by a pin closure member 56, adjustable by screwing of a closure-member holder 57. The minimum pressure tolerated for correct operation of the valve unit is regulated by the pin closure member 56.

**[0024]** In operation, the control pressure Pt in the chamber 22 is generated as described fully above and in a similar manner for the valve units of both embodiments described. This control pressure Pt is transferred by the transfer duct 26 to the control chamber 9. If, for example, the pressure in the control chamber is increased as a result of an increase in the pressure Pt, this pressure acts on the diaphragm 8, urging the closure member 5 to

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open. The partial opening of the closure member 5 brings about a corresponding increase in the delivery pressure and consequently in the flow-rate of gas delivered, as a result of a reduction in the pressure losses. Naturally, as a result of a decrease in the control pressure there will be an increase in the above-mentioned pressure losses since the closure member 5 is urged into closure on the seat 6, with a consequent proportional decrease in the delivery pressure and in the flow-rate. For each mean value of the control pressure  $P_t$ , modulated in the manner described, a proportionally correlated mean delivery pressure and flow-rate are thus achieved.

[0025] The invention thus solves the problem set, achieving many advantages in comparison with known solutions.

[0026] A first advantage is that, with the valve unit of the present invention, a modulation of the gas delivery pressure and flow-rate is achieved by means of a driver circuit supplied with thermoelectric energy within the system and does not therefore require any external supply. This advantageously eliminates both the use of the mains electrical supply which, in the event of interruption, would not ensure safe operation of the valve unit, and the use of battery voltage generators for supplying the pressure-modulation device. As a result, it is also possible to achieve advantageously low consumption because of the low power required for the control of the modulation valve.

[0027] A further advantage is that the valve unit of the invention ensures the pressure-modulation function by the operation of a single modulation valve, with consequent structural simplicity and low costs.

### Claims

1. A valve unit for modulating the delivery pressure of a gas, comprising:

- a servo-valve (4) having a closure member (5) with diaphragm control (8), the diaphragm (8) being subjected, on one side, to the gas-delivery pressure and, on the other side, to a control pressure ( $P_t$ ) established in a control chamber (9) of the servo-valve (4),
- a pressure-regulation device associated with the servo-valve and comprising a modulation valve (10,51) for modulating the control pressure, and consequently the gas-delivery pressure,
- actuator means for the operative control of the modulation valve (10;51),
- a circuit (39) for driving the actuator means, characterized in that the driver circuit (39) comprises means for generating an operative modulation-valve driving signal (S) of constant frequency, with a preselected period (T), and means for duration modulation of the signal amplitude within the period (T) so as to modulate the control pressure ( $P_t$ ) in a proportionally correlated manner.

2. A valve unit according to Claim 1, in which the amplitude of the driving signal (S) is variable, within the period (T), between a maximum value and a minimum value, the values being adopted in a first time interval (T1) and in a second time interval (T2), respectively, the durations of the time intervals being adjustable, and the ratio (D) between the durations of the intervals being correlated proportionally with the value of the control pressure ( $P_t$ ) generated in the control chamber (9).

3. A valve unit according to Claim 1 or Claim 2, further comprising an ON-OFF valve (52) for shutting off the gas, the ON-OFF valve communicating with the control chamber (9) and being interposed between a gas-inlet duct (2) and the modulation valve (51), the modulation valve (51) being driven by the driver circuit (39) purely for the function of modulating the control pressure ( $P_t$ ).

4. A valve unit according to one or more of the preceding claims, in which the driving signal (S) is an electrical voltage signal.

5. A valve unit according to one or more of the preceding claims, in which the first (T1) and second (T2) time intervals are in sequence with one another, the sum of their durations being equal to the period (T) of the signal (S), the signal (S) being continuous in each of the intervals (T1, T2).

6. A unit according to Claim 5, in which the driving signal (S) adopts an amplitude of zero value in one of the intervals (T1, T2).

7. A unit according to one or more of the preceding claims, comprising safety valve means (11) controlled by thermogenerator means (12a, 12b) in order to supply sufficient energy to bring about opening of the valve means (11) in the presence of flame, the driver circuit (39) of the modulation valve (10, 51) being supplied by the thermoelectric energy generated by the thermogenerator means (12a, 12b).

8. A unit according to Claim 7, in which the thermogenerator means comprise at least one thermocouple (12a).

9. A unit according to Claim 7, in which the thermogenerator means comprise at least one thermopile (12b).

10. A unit according to one or more of Claims 4 to 9, in which gas-flow restricting means (56) are provided between

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the modulation valve (51) and a gas-delivery duct (3), the restricting means being adjustable in order to control the minimum gas-delivery pressure.

5 11. A unit according to Claim 1, in which the actuator means comprise an electromagnet which can be supplied with the driving signal (S).

12. A unit according to Claim 1 in which the actuator means are piezoelectric.

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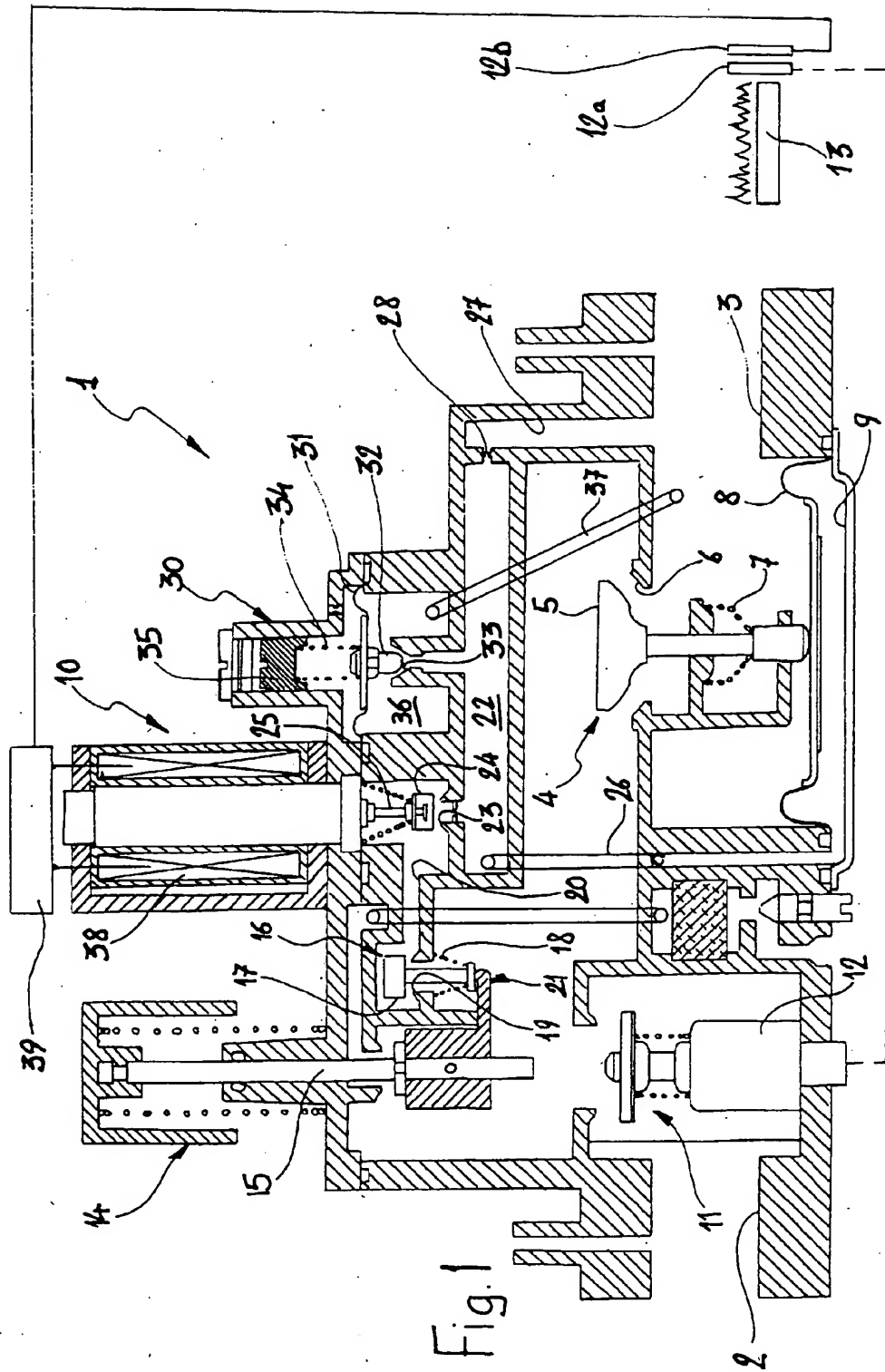
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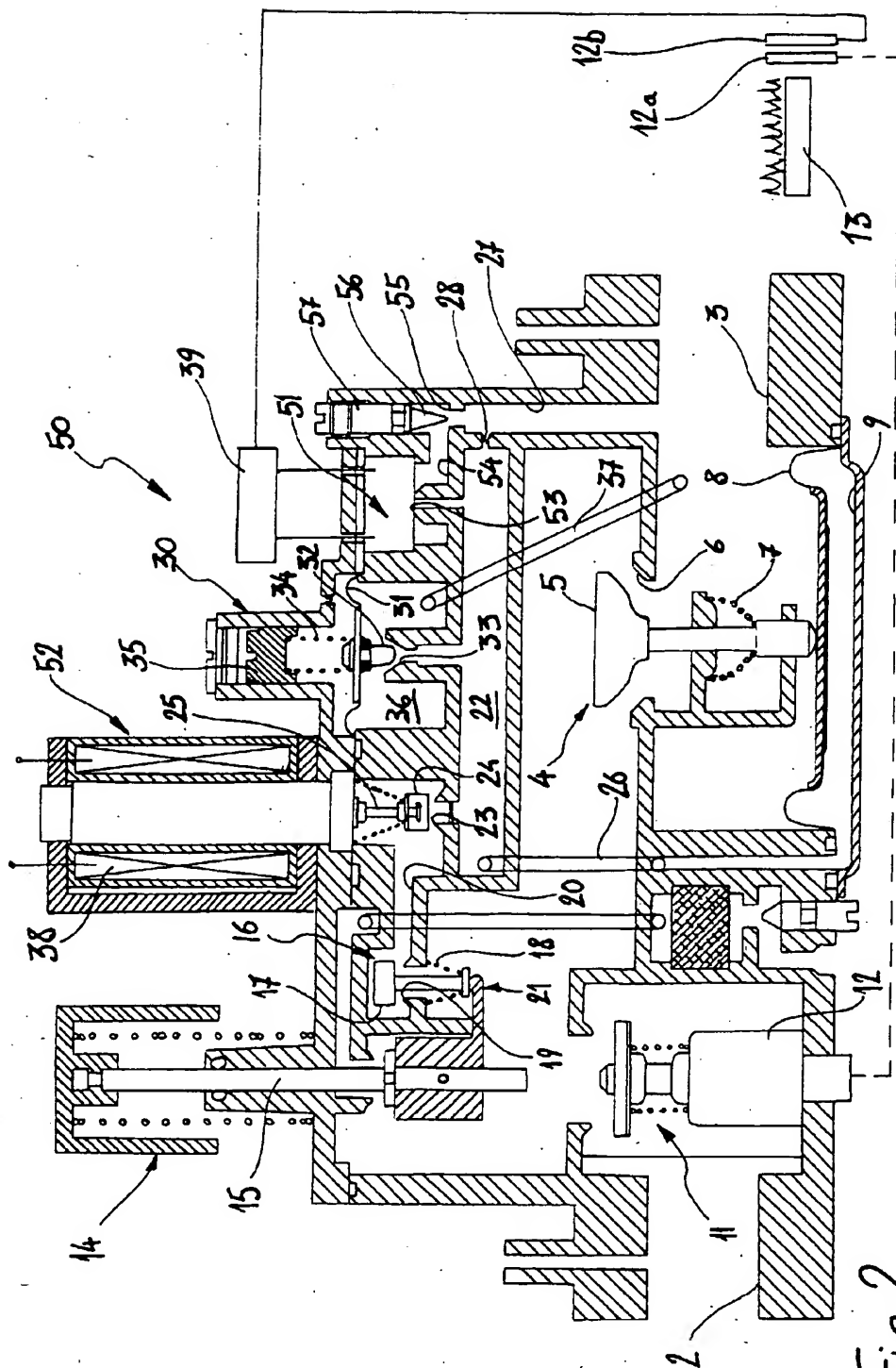
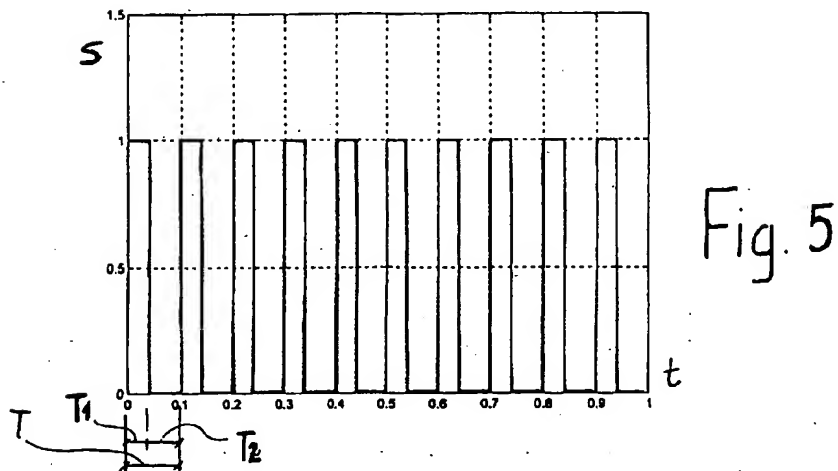
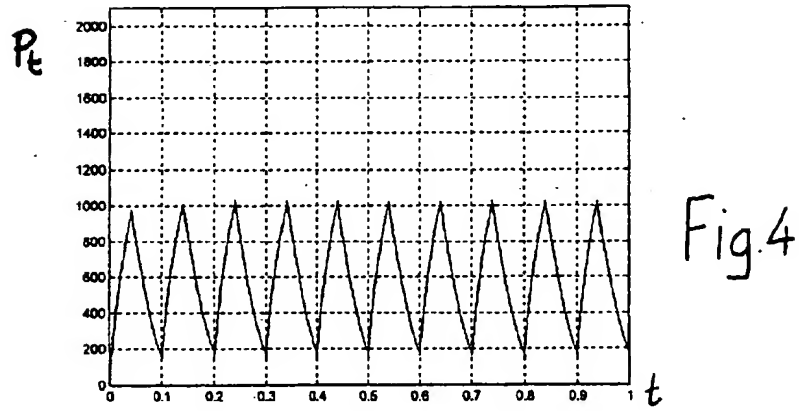
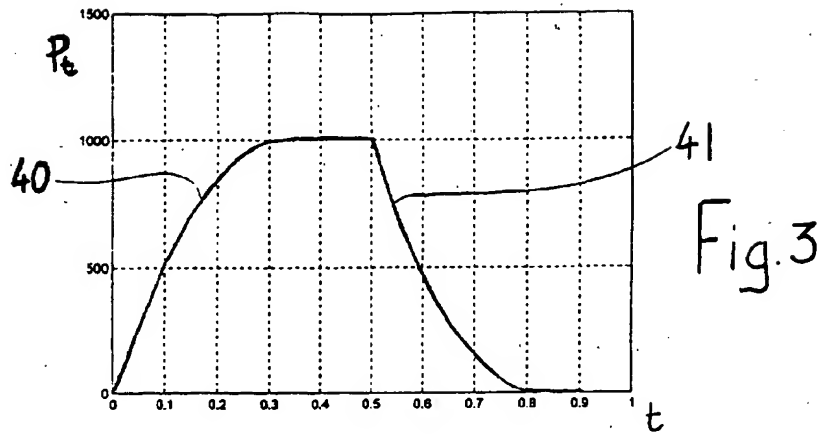


Fig. 2





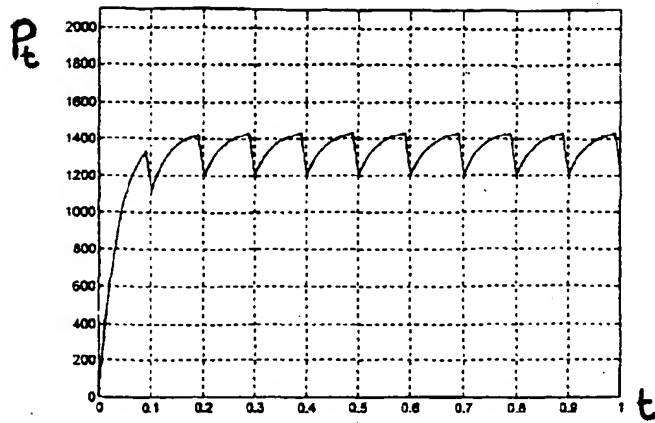


Fig. 7

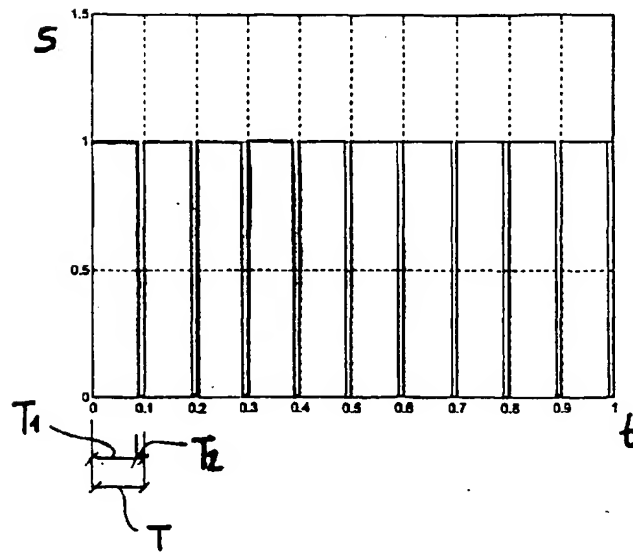


Fig. 8

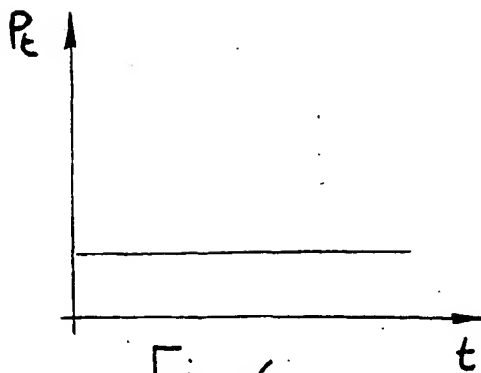


Fig. 6

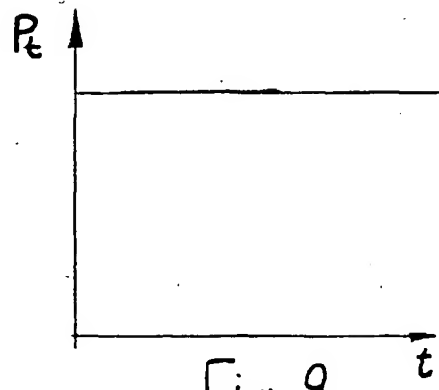


Fig. 9



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Application Number  
EP 99 12 0258

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<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone  Y : particularly relevant if combined with another document of the same category  A : technological background  O : non-written disclosure  P : intermediate document</p> <p>T : theory or principle underlying the invention  E : earlier patent document, but published on, or after the filing date  D : document cited in the application  L : document cited for other reasons</p> <p>&amp; : member of the same patent family, corresponding document</p>			

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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